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Farm and Home Research

South Dakota State University Agricultural  
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## Farm and Home Research: 53-4

Mary Brashier

Lance Nixon

Marianne Stein

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Utilizing and developing our resources to enhance quality of life

# Farm & Home RESEARCH

Volume 53 • Number 4

South Dakota State University • College of Agriculture & Biological Sciences • Agricultural Experiment Station



## RAY MOORE 4

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a family man, an honest man

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Decrease feeding costs and increase quality and productivity

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Biotechnology creates tomorrow's crop varieties

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This issue of *Farm & Home Research* honors the late Dr. Ray Moore, director of the South Dakota Agricultural Experiment Station for 20 years. The photo on page 4 depicts this family man with son Jay and grandson Danny. Photo by Melby Portraiture.

## On the cover:

Since the cost of corn and soybean meal has soared due to the drought, producers are increasingly looking at distillers grains and other industry byproducts to stretch feed supplies for dairy, beef, and swine. Either wet or dry, the distillers grains are generally affordable and make a high-quality, nutritional feed supplement.

### South Dakota State University

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Fred Cholick

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Experiment Station

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Associate Dean  
Director, Cooperative  
Extension Service

Don Marshall

Associate Dean  
Director,  
Academic Programs

### Farm & Home Research Staff

Barbara Suhr Hartinger

Executive Editor

Mary Brashier

Editor

Lance Nixon

Writer

Marianne Stein

Writer

Terry Molengraaf

Graphic Designer

Penny Miller

Circulation

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# Director's comments

BY KEVIN KEPHART

*Director, South Dakota Agricultural Experiment Station*



Kevin Kephart

## A Man We Honor

Knowing I wanted to share my thoughts about Ray Moore, former director of our Agricultural Experiment Station, in this column, I leafed through some back issues of this magazine to read what he said in his 20 years in this office.

In the 1980s he was talking about value-added agriculture. In 1982 he discussed ethanol. Something caught my eye in that column. He mentioned the Jerusalem artichoke.

Ray wrote that he was getting letters and phone calls from advocates of the plant, not an artichoke at all and certainly not from Jerusalem. It's a native North American member of the sunflower genus; you may know it as "sunchoke." Or, now that the furor has died down, you may not know it at all.

Back in the early 1980s, its supporters firmly believed it was the alcohol fuel or fuel additive of the future. Ray Moore was indeed a visionary—that's one thing that made him such a powerful Experiment Station director—but he tempered that vision with realism. There was no more room to fit more projects into an already strained research program. He simply said, "Other things have higher priorities."

Today, our scientists also face an unlimited number of research problems with just as few financial and human resources. If it must become necessary, I hope I can also say: "Other things have higher priorities."

Ray went one step farther. In nearly every column he wrote for this magazine, or when he talked to you or wrote you a letter, he would ask for your feedback, your comments on how the Experiment Station could meet your needs and concerns. You could agree or disagree, but he wanted to know what you were thinking. I also ask you to write, call, or come. We all are cooperators working together to build a better South Dakota.

I knew three different sides of Ray Moore. He expected the best from everyone, often an intimidating role to a new, young faculty member. He also had high expectations for his college and this university. On the hundredth anniversary of South Dakota State University, he wrote, "SDSU is more than young graduates, 4-H youth, homemakers' clubs, beef cattle performance testing, new crop varieties, community planning. It is more than hope for the future; it is the means to reach it." Yes, he looked to the horizon.

Later, after I'd been here a while, I got to know him in a different light, as a fellow scientist and friend. I remember one day when we stopped in at the old Norbeck field station. Ray established the Norbeck station. He was proud of the place; he showed us around, and some of his alfalfa interseeded plots were still visible—contributing nitrogen to the soil and additional forage plants to the pastures. We were there 13 years after the station had closed in 1985.

And finally, I knew him as a retired director ever ready to help a new and somewhat overawed Experiment Station administrator. He was one of the first people I talked to when I had a problem—or an idea I thought was brilliant. I asked his opinion of the Sun Grant initiative. He was enthusiastic and said it would be worthwhile but promised it'd be a lot of work. Later, when I went through his files of correspondence with the politicians of his day, I found out why he seemed so familiar with the topic. He'd thought up a similar concept nearly 30 years ago.

We both came from forage backgrounds but that's where it ends. He was a genuine product of the soil, from a farm near Britton. I had a flock of ewes and some pasture and forest land but no cropland when I was growing up. He started his career as a vo-ag teacher, and for a time vo-ag was what I lived for; I attribute much of my career to my vo-ag teacher-mentor, and I appreciate and understand how deep and sincere was Ray's love of teaching young people.

Not that he couldn't put a budding young scientist in his place. When I came to SDSU I very quickly learned that he believed if you came from a large, well-endowed university, as I did, you shouldn't think you knew it all. In fact you knew very little about South Dakota, and you better learn fast if you wanted to stay.

He was right, and I'm still learning.

A "Ray Moore fund" has been set up through the SDSU Foundation. Get in touch with me if you'd like to help honor this man with a contribution. He was an untiring advocate of South Dakota agriculture and devoted to enhancing your quality of life, whether you knew him personally or not.

And, if you knew another side of Ray, I'd appreciate learning your recollections about this man so many of us respect. ♦



# Ray Moore

A mentor, a scientist, a visionary, a family man, an honest man  
by Mary Brashier

**Ray Moore**, director emeritus of the South Dakota Agricultural Experiment Station and former high school and college teacher and forage agronomist, died Saturday, October 19, 2002, at the Brookings Hospital after a battle with cancer.

Best known as Experiment Station director from 1973 to 1993, he was an advocate of agricultural education and research when speaking to appropriations committees and the Board of Regents and when visiting with citizen, community, and commodity groups and students and their parents.

He never worried about what he would say. His credo was absolute, blunt honesty. "You must be honest. Then you don't have any trouble remembering what you said."

And he believed wholeheartedly in the mission of the Experiment Station, often closing his talks and writings by expressing its continuing mission: to conduct research to enhance the quality of life in South Dakota through beneficial use and development of economic, human, and natural resources.

The "human resources" were more important to this research director than many people realized.

He saw himself as a teacher first and an administrator second. Of the many awards he received over the years, his most treasured was 1968 "Teacher of the Year" for SDSU, at a time when only one such award was given across the University.

"Ray often said this was the greatest honor he'd ever received because it was directly from the students," remembered Fred Cholick, dean of the College of Agriculture and Biological Sciences.

"He probably influenced my thinking more than anyone else in understanding that the human resource is our most important of all resources."

After Moore's retirement in 1993, Cholick took over as Experiment Station director before moving up to the deanship.

"He was a hard act to follow," Cholick admitted. "His vision reached beyond the borders of South Dakota. He was a leader among ag experiment station directors in other states.

"Most of all, he helped us to see how we as scientists and teachers here at SDSU fit into the larger picture of worldwide food production, how we should serve our local and global community, and how we should commit ourselves to the well-being of all humanity.

"Ray believed that our research, our development of new knowledge or products, should benefit both the individual and our communities as well. He believed in South Dakota. He spent his entire career making it a better place for all of us who would come along after him," Cholick said.

As 20-year director of the Experiment Station, Moore administered at any one time the work of about 150 scientists and their graduate students, 20 or so adjunct faculty, and seven outlying research stations. From his first week in the job, he stressed to the scientists that that he and they would be guided by the words productivity and accountability, ultimately answering to South Dakota citizens for their work.

He was both realistic and optimistic about the future of South Dakota agriculture. "Science won't solve all the problems, but people—using science—will," he said. His visionary outlook popped up often enough for listeners to recognize his favorite future projects.

He believed in perennial wheat—someday. He believed in corn that provided its own nitrogen fertilizer. "Actually, it already exists," he said in 1993. "It just doesn't produce an ear.

"That's a major problem," he deadpanned.

He spoke, "I am confident that these and other agricultural advances will happen. If we have the time to spend on improving quality of life in South Dakota and the world, the impossible becomes possible and the possible becomes a virtual certainty."

He believed in biotechnology before it became a buzzword. He was reluctant to admit it, but he probably coined the word "biostress."

His was the initial concept and the continuing drive to fund and build the Northern Plains Biostress Laboratory at South Dakota State University, a building he called "only bricks and mortar," preferring to name the research staff, Extension specialists, and students who learned, shared ideas, and worked together on the stresses inflicted by the environment on South Dakota plants, animals, and humans.

"With all he did for the rest of us—school and state, Ray still had a personal life," Cholick said. "He fished and hunted with his boys every chance he got—his family was 'first' for him. He was an elder in his church. He worked hard in several service organizations. And he believed that all faculty, staff, and students at SDSU should also be service-oriented.

"That dedication to service was an inspiration to all of us who knew him well."

Moore graduated from South Dakota State College, and after a 5-year stint as vo-ag instructor at Bennett County High School in Martin, returned to SDSU as agronomy instructor. He became head of the Plant Science Department in 1968 and took over the reins of the Ag Experiment Station in 1973.

"He would say his greatest legacy at the University is his students. We would say it's the man himself—his commitment to research, to SDSU, and to all South Dakota citizens," Cholick said. ♦



# Reflections

## on changes in farming and agricultural research

*Excerpts from a 1996 presentation by Ray Moore at the Sewrey Colloquium, an annual lecture series at which invited faculty members discuss scholarship, inquiry, and the universality of ideas.*

**The changes that have taken place** in South Dakota agriculture in the last 40 years are astonishing .... Consider what these changes must look like to someone who left the state 40 years ago and who has just come back.

The few windmills that remain look pretty tattered. Fencelines, even section lines, have vanished in many places. Farm machinery the visitor can't name, let alone guess the function of, work in giant fields. Cattle seem to be a strange mixture of unknown breeds, although they look

sturdy and healthy. "Soybeans" weren't even known 40 years ago.

Entire farmsteads have disappeared. So have the country schoolhouses. Whole blocks along small-town mainstreets are boarded up.

The visitor will surely wonder, “Is all this change good?” [South Dakota agriculture has been] in the process of change from the time the earliest homesteaders learned they had to [buy] up the neighbor’s property, for 160 acres produced only subsistence farming in Dakota Territory.

Farmers are still buying up more land whenever they can. This need to grow is the basis of the most apparent change in South Dakota agriculture: There are fewer farms and ranches, and they are larger. The impact of increasing farm and ranch size is also felt past the farm gate—among all rural institutions, including schools, churches, and local government.

I acknowledge that some of these changes, particularly the loss of the family farm, have been heartbreaking to see and experience.

**BUT WHAT IF** these changes had not occurred?

Change occurs where there is industrialization, other employment opportunities, and economic growth. A stagnant economy does not encourage change.

Change also occurs where the political climate allows it to happen. The free enterprise system in the United States encourages entrepreneurial development and growth of personal management and innovative skills. We are fortunate that we live in a country where we have choices, painful or not, to make. ...

We at land-grant universities can be credited or blamed for technological change. I have been accused of being one of the perpetrators of bigness in agriculture.

I admit that we in ag research have contributed to these changes. We developed technology to produce more food, to protect the food, and to protect our resources. The farmers and ranchers who picked up our new management options or new varieties benefited more than those who chose not to. In our democratic society the individual is able to exercise his freedom and his personal innovative or entrepreneurial skills. ...

The heart of the matter is that neither ag research nor machinery companies can take the credit or the blame for “bigness” in agriculture. In fact, farmers themselves started this movement. They are the greatest innovators, entrepreneurs, and inventors of all.

**OUR RETURNING SOUTH DAKOTAN** would be overwhelmed by the quantity and quality of agricultural research now coming out of the South Dakota Agricultural Experiment Station.

Forty years ago we had fewer and less accurate tools, and we waited seasons, and even years, for plants and animals to grow and show us whether we had accomplished our relatively modest aims. Mostly, those aims were added bushels per acre or higher weights at slaughter. Those were the primary needs of farmers and ranchers in South Dakota at that time, and we were responding to those needs.

Now, with 40 years behind us, we know that there are many more ways than increased yields to achieve a high quality of life and sustained profitability from agriculture. And we have the tools to reach those goals, from satellites taking photographs of our fields to enzymes that snip and cut genes out of chromosomes.

**I CONTINUE TO BE OPTIMISTIC** about agriculture and agricultural research. I am optimistic for many reasons, primarily because all mankind must eat.

I remember the first lecture I ever gave; it was back in 1956. I also remember my last one; it was in 1994. They were essentially the same lecture. ...

I talked about the billions of factories that we have in South Dakota. Those factories carry on their business without any fanfare at all. They have no labor problems or strikes, they cause no pollution; in fact, they abate pollution.

I talked about those billions of green plants that produce food, by combining carbon dioxide and water from the air and soil in the presence of sunlight and the green coloring matter, the chlorophyll, within the plant. How they manufacture food from these simple elements wasn’t understood in 1956; 38 years later at my last lecture, it was still not understood.

We can do many things. We can build skyscrapers, great bridges, can travel faster than birds, in fact, faster than sound. We have been to the moon. We can harness mighty rivers for recreation and power. We can do almost anything. But we cannot manufacture food. We cannot survive without eating, we cannot survive without those billions of tiny factories.

As Experiment Station director, I was often asked to make predictions. I no doubt made more than I should have. I was not always right, and I will never live long enough to know about others.

At a crops meeting in Aberdeen, I predicted that we would some day take desirable qualities from one plant and put them into an unrelated species. I thought it would take at least 10 years to make that happen.

Within 6 months, it had been accomplished in bacteria. It’s now being done in higher plants and animals. We call these transgenic plants and animals, and some of them are already on the market.

I predicted that someday we would be able to teach corn to produce its own nitrogen like legumes do. I was also optimistic about the development of perennial crops and some other innovations. These kind of things will not happen quickly, and they will not happen without considerable financial support.

If time is not a factor, I am confident that these and other agricultural advances will happen. If we have the time to spend on improving quality of life in South Dakota and the world, the impossible becomes possible and the possible becomes a virtual certainty.◆



Distillers grains contain up to 10% more energy than corn, about 30% crude protein, and 10% fat, according to Arnold Hippen, left, SDSU dairy scientist, and Alvaro Garcia, SDSU Extension dairy specialist. Hippen devised different dietary levels of distillers grains, searching for the "upper limit" of the feed that lactating cows will handle.



# Distillers grains:

'Just because you're out of hay doesn't mean you're out of the cattle business'

by Marianne Stein

**Hay shortages and high feedstuff prices** are the norm this winter and spring. But there are ways to get around them. Industry byproducts such as distillers grains and soybean hulls make affordable, high quality feeds, South Dakota State University scientists say.

Distillers grains from ethanol plants especially catch their attention.

"They are a good protein and energy feed, they are readily available in South Dakota, and they are certainly priced very competitively with other feeds," says David Schingoethe, professor of dairy science.

Corn is two-thirds starch, and during fermentation and distillation the starch is converted to ethanol and carbon dioxide. The leftovers, called spent mash, are centrifuged to remove as much liquid as possible. The remaining solid material can either be used directly or in a dehydrated form.

Distillers grains can be purchased as wet distillers grains (WDG), dried distillers grain (DDG), or dried distillers grains with solubles (DDGS).

Distillers grains contain about 10% more energy than corn, according to research data from South Dakota State University and elsewhere. They have about 30% crude protein and 10% fat, and they are a source of phosphorus, reducing or eliminating the need for phosphorus supplements in the diet.

The energy in distillers grains is primarily in the form of fiber and fat rather than starch, making the byproduct desirable for cattle on forage-based diets. Starch can interfere with fiber fermentation in the rumen and lead to problems like acidosis and other metabolic disorders.

**FOR BEEF CATTLE**, distillers grains can be used in the feedlot or as a supplement to a forage diet for grazing cattle. The product can replace corn and soybean meal as protein and energy sources and can be fed to beef cattle of any age.

Scientists at South Dakota State University, funded in part by the South Dakota Corn Utilization Council for feeding trials and the South Dakota Beef Industry Council for carcass studies, have investigated how different levels of distillers grains affect performance of feedlot animals.

The control group received a finishing diet consisting of corn, soybean meal, mineral supplements, and about 10% forage. In the treatment groups, all of the soybean meal and part of the corn were replaced with either 20% or 40% of the total diet as distillers grains. Both wet and dried versions were used, explains Kent Tjardes, South Dakota State University Extension beef feedlot specialist.

Preliminary results indicate that performance was very similar across all groups, says Tjardes. All animals in all groups had similar gains and consumed similar amounts of feed, leading to the same feed efficiency. Cattle in all groups had similar dressing percentage, hot carcass weight, and ribeye area, and there were no significant differences in marbling (quality grade).

“We concluded that it is possible to add up to 40% distillers grains in the diet and still get successful gain and performance,” says Tjardes. Going past 40% may cause



Kent Tjardes, SDSU Extension beef feedlot specialist, says beef cattle of any age can gain on distillers grains at up to 40% of the diet.

waste management problems because of excess nitrogen and phosphorus, he cautions.

“There is enough phosphorus in corn that we are already above the requirements in a normal corn-based finishing ration. So if you feed too much distillers grains, you will run into problems handling excess phosphorus in the manure,” says Tjardes.

With grazing cattle, the high fat content of distillers grains limits how much you want to use, says Cody Wright, South Dakota State University Extension beef specialist.

“Grazing cattle have more roughage in the diet. High-starch feeds will alter the rumen microbial population, resulting in depressed forage intake and digestibility. Since distillers grains contain little if any starch, forage utilization is not affected. However, rumen microbes are sensitive to fat, so 10 pounds of distillers grains, or about 20% of the total diet, should be the maximum.”

**“They are a good protein and energy feed, they are readily available in South Dakota, and they are certainly priced very competitively with other feeds.”**

—DAVID SCHINGOETHE,  
SDSU DAIRY SCIENCE PROFESSOR

**“Producers often ask if there is a way to decrease feeding costs and increase quality and productivity. Usually that doesn’t work, but in this case it does. You can drop your production costs, you can increase your quality, and you can produce more milk by using distillers grains.”**

—ALVARO GARCIA,  
SDSU EXTENSION DAIRY SPECIALIST

Distillers grains also work well in limit-fed beef cow diets. “You can buy cheap forage and use that as a filler. The nutrient demands of the cow will be met by the corn and distillers grains, but you want to have at least half a percent of body weight—6.5 to 7 pounds—of roughage in the diet,” Wright recommends.

**IN A TYPICAL MILKING HERD DIET**, “roughly half of the dry matter is forage such as corn silage or alfalfa hay, and the other half is concentrate mix. We don’t recommend feeding distillers grains as the only concentrate, but there is evidence you can add about 20% distillers grains and still have a nutritionally sound diet,” says Schingoethe.

“The general question producers ask is ‘how much distillers grains can you feed?’ but nobody had studied the upper limit,” says Arnold Hippen, assistant professor of dairy science.

Hippen and his colleagues recently completed a research trial, funded by the South Dakota Corn Utilization Council, with lactating dairy cows to find that maximum. On a dry matter basis, the diets contained 10, 20, 30, and 40% distillers grains. The diet with the highest amount included almost 70 pounds wet distillers grains, while the test diet with lowest amount of distillers grains resembled a regular South Dakota dairy cattle diet.

“Increasing WDG above 20% of dry matter decreased dry matter intake and yield of milk and milk components,” Hippen says.

The scientists also found that concentrations of fat, protein, urea nitrogen, and lactose in milk did not change with diets; however, yields of milk fat, lactose, and urea nitrogen were decreased by increasing WDG in the diet.

The scientists measured how much phosphorus and nitrogen showed up in the manure at the different test levels. Too much phosphorus and nitrogen in the waste create potential environmental problems. “If you feed

too much distillers grains, you are over-feeding protein, and that is not environmentally sound,” Hippen says.

The distillers grains replaced corn and soybean meal as the concentrate supplement in a diet of corn silage and grass hay. “We did not want to use alfalfa hay because of its high nitrogen content, adding to that already provided by the distillers grains,” Hippen adds.

Alvaro Garcia, South Dakota State University Extension dairy specialist, adds that a producer who wants to use distillers grains should balance the diet and adjust the rest of the feed ingredients accordingly, removing phosphate supplements, for example.

Distillers grains are a good way to stretch forage supply in the drought year, Garcia says, because they make an affordable yet high quality feed.

“Producers often ask if there is a way to decrease feeding costs and increase quality and productivity. Usually that doesn’t work, but in this case it does. You can drop your production costs, you can increase your quality, and you can produce more milk by using distillers grains.”

Whether distillers grains can completely substitute for soybean meal depends on production level and forages fed, Garcia says.

“Some cows might still need soybean meal, because it provides protein that is degradable in the rumen. But most South Dakota producers are at a production level where they can use distillers grains and do as well as they would with soybean meal.”

Distillers grains are not recommended for young dairy animals, he adds.

“We have been testing it with heifers. The problem is that they gain a lot of weight even when fed relatively small amounts of distillers grains. Heifers should not gain more than 1.8 to 2 pounds per day. If they gain too much weight, there will be too much fat deposited in the mammary gland and that will impair future lactation performance. You can use distillers grains for yearlings and up, but I wouldn’t yet recommend them for really young dairy stock.”

**“Whether people are getting a truckload or only a couple of tons, they should take a sample and have it analyzed, so they know what they have.”**

—CODY WRIGHT,  
SDSU EXTENSION BEEF SPECIALIST

**CHOOSING WET OR DRIED** distillers grains depends on the availability and cost of other feed sources and storage and handling facilities on the farm.

Wet distillers grains mix well with other feeds, says Tjardes. However, WDG spoil quickly—in 4 to 5 days—so they are best suited for immediate use. If stored, they should be inside or under cover. Storing WDG in silo bags is also an effective preservation method.

WDG are also more suitable for operations close to an ethanol plant. The byproduct is 65-70% water, uneconomical to ship long distances.

Dried distillers grains are easier to handle. They can be stored longer and shipped over longer distances. Their consistency is like ground coffee, so they also need to be stored out of the wind. They should be fed in a feed bunk or mixed with other feed.

“You might not want to store DDG for a year, because they have a lot of fat, and fat can become rancid. But you can certainly store them for several months without problems,” says Tjardes.

DDG don’t mix well with other dry products but can be used with wet products such as corn silage, grass silage, or wet molasses.

For both wet and dry types, the scientists recommend that a sample of each shipment be analyzed. As with all byproducts, there will be some variation in nutritional content.



Choice of wet or dry depends on producer's preferences, storage facilities, and distance from an ethanol plant.

“Whether people are getting a truckload or only a couple of tons, they should take a sample and have it analyzed, so they know what they have. Then they can adjust the diet accordingly,” says Wright.

**SOYBEAN HULLS**, available as byproducts from soybean processing plants, are also a useful feed supplement. They are a good, highly digestible fiber source, but because of their very small particle size, they should not be used in large quantities.

Soybean hulls are an ideal supplement to distiller's grains, explains Garcia.

“We combined WDG with dry soybean hulls at a 50-50% dry matter basis, and we got an excellent feed. It preserves really well.”

Garcia also tried pelleting DDG and soybean hulls together.

“The problem with distillers grains is that because they have 10% fat, they are very difficult to pellet. They will not hold together. When you mix them with soybean hulls, you decrease the fat by half. Then you can pellet the mix, and you have a product that has close to 20% crude protein, which makes it more acceptable for different feeding situations.”

Garcia and colleagues also evaluated fermentation and preservation characteristics when ensiling WDG with corn silage. “Ensiling WDG with corn silage could be effective,” Garcia says. “A mix of WDG and corn silage at a 50% ration resulted in a low initial pH and high acetic acid concentration, indicating that preservation can be enhanced by combining the feedstuffs.”

Distillers grains, soybean hulls, and other industry co-products are becoming increasingly popular as ingredients in feed concentrates, and more and more producers are using them.

“Typically the most challenging thing is to find them,” Wright says. “We suggest that producers call around to direct suppliers, like nearby ethanol plants. And that they consult their Extension educator or nutritionist to determine their best individual strategy.”

“All these feeds work extremely well. It is just a matter of how cheap you can get them. You can work with different combinations, depending on what other feed sources you have available.

“Just because you're out of hay doesn't mean you're out of the cattle business.” ♦



Bob Thaler, SDSU Extension swine specialist, offers a treat. Distillers grains may be ideally suited for swine, he says.

# Distillers grains:

## Swine producers can 'take the edge off' feed bill

by Marianne Stein

**It might pay swine producers to switch** to different feedstuffs this winter and spring. Dried distillers grains, grain sorghum, field peas, canola meal, canola seeds, soybean hulls, barley, and wheat middlings can take the edge off the feed bill, says Bob Thaler, South Dakota State University Extension swine specialist. The drought has boosted the costs of corn and soybean meal.

Thaler and Hans Stein, South Dakota State University swine nutritionist, have conducted research with most of these alternative feeds and can provide recommendations based on trial results.

They also recommend phytase to reduce phosphorus supplements, shaving costs more.

**DISTILLERS GRAINS** have mostly been a cattle feed but may be even more ideally suited for swine, Thaler says.

Distillers grains contain three times more phosphorus than cattle require. Swine, however, can utilize all the digestible phosphorus in distillers grains, eliminating most problems of excess phosphorus in the manure.

Dried distillers grains with solubles (DDGS) are co-products of the ethanol industry and are increasingly popular as feed ingredients. “It is fairly new to use distillers grains for pigs, because in the past the quality wasn’t good enough,” says Thaler.

Today’s distillers grains from South Dakota and Minnesota ethanol plants are much higher in nutritional value. And with the expansion of the ethanol industry in South Dakota, they are also locally available at an affordable price.

Distillers grains replace mostly corn and some soybean meal in swine diets. “You can use about 20% distillers grains for nursery pigs, 20-30% for grow-finishing pigs, 20-30% for lactating sows, and up to 40% for gestating sows,” Stein says.

Distillers grains are fairly low in lysine, an indispensable amino acid for pigs, so it may be necessary to add extra

lysine to the diet. Consequently, the cost of synthetic lysine will determine how much DDGS to use, Stein says.

“Pigs require amino acids, not protein, so swine diets need to be balanced on a lysine or digestible lysine basis, not on crude protein,” Thaler adds.

DDGS are well suited for gestating sows, because these animals have a low lysine requirement. “Basically, we can meet the sow’s requirements for lysine and digestible phosphorus by using distillers grains as the sole amino acid source,” Thaler says.

DDGS don’t taste like corn, so producers should start out with 10% DDGS and gradually increase the amount to let the animals get used to the taste and avoid problems with refusal, Thaler recommends.

Thaler notes that DDGS may provide an additional health benefit to pigs.

“Some producers have noticed that DDGS seem to reduce problems with ileitis, a bacterial infection that can cause bad scours and eventually death. So far there is only anecdotal evidence, but we are undertaking a study to investigate the issue.

“We suspect that the beneficial effect might be caused by yeast left over from the fermentation process. In Europe, yeast is sometimes used instead of antibiotics to treat bacterial infections.”

Another theory is that the fiber in DDGS is responsible for the beneficial effects, Thaler adds.

Thaler and Stein have just started the project, which received funding from the South Dakota Corn Utilization Council.



Hans Stein, South Dakota State University swine nutritionist, weighs distillers grains to use in swine feed for a DDGS trial.

## **“It is fairly new to use distillers grains for pigs, because in the past the quality wasn’t good enough.”**

—BOB THALER,  
SDSU EXTENSION SWINE SPECIALIST

Thaler has developed a DDGS cost calculator for swine feed, which is available through Extension educators or online at <http://ars.sdstate.edu/swineext/ddgs.htm>

**FIELD PEAS** are an ideal swine feed. They are locally grown, available through feedstuff companies, and currently very affordable.

It is best to purchase field peas as an ingredient in pelleted feed, because pelleting increases the nutrient digestibility of the peas, Stein says. Field peas contain approximately 22% protein. They are high in lysine but low in methionine, another indispensable amino acid.

Field peas can replace corn and soybean meal if the producer adds methionine and l-threonine and removes some lysine. Stein points out that, as when making any other changes in the feed, it is important to balance amino acids and minerals in formulating the diet.

Stein and Thaler recently concluded several experiments with field peas. “Our research shows that for nursery pigs from 2 weeks post weaning and for growing-finishing pigs, you can include up to 36% field peas without negative effects on performance. We also saw a slight improvement in carcass leanness compared to pigs on a corn-soybean meal based diet,” Stein says.

He adds that Canadian and European experiences indicate that it is possible to include 10 to 20% field peas in sow diets, but no research has been conducted at South Dakota State University with such diets.

Grain sorghum is another good feed for pigs. “It is a ‘hot, dry crop,’ meaning it grows well under hot, dry conditions in the southern part of South Dakota,” Thaler says. “Sorghum has the same feeding value as corn, and it can replace corn on a pound-per-pound basis. A producer needs to look at cost per pound to determine whether it is preferable to corn.”

Barley is locally grown and works well as a swine feed ingredient. It is higher in lysine than corn, and it can replace most corn and some soybean meal in the diet.

**CANOLA**, grown in North Dakota and Canada, is another good ingredient in swine diets.

“Canola meal is a protein concentrate; it contains approximately 36% crude protein and a high level of methionine. Canola seeds contain approximately 21%

crude protein. They have a very high energy content because they contain oil, and that is especially beneficial for lactating sows,” Stein says.

“Our research shows that you can use 12% canola meal or 15% canola seeds in sow diets. We have used canola for gestating and lactating sows with no negative consequences on milk production, weaning weight of piglets, or the sow’s reproductive performance.”

However, he does not recommend going much above these numbers. “There are anti-nutritional factors present in canola. It is high in glycosinolates, which interfere with the digestibility of protein,” he explains.

Canola meal replaces mostly soybean meal, while canola seeds replace both soybean meal and corn. Amino acids in the diet also need to be balanced.

Soybean hulls and wheat middlings can also be added to swine rations in small amounts. “Research has indicated that you can use 10% soybean hulls for finishing pigs, mostly replacing corn,” Stein says. He adds that other research indicates that up to 20% soybean hulls for gestating sows and 5-10% for lactating sows and for growers are acceptable.

Soybean hulls should not be used for weanling pigs. Soybean hulls contain more lysine but less methionine than corn. They are low in energy and protein.

“Because soybean hulls are low in energy and high in fiber, you can’t add too much because the pigs won’t be able to eat enough to meet their energy requirement,” Stein says.

**SYNTHETIC PHYTASE** could lower feed costs.

Phytase is an enzyme that increases digestibility of natural phosphorus, so it can replace some of the inorganic phosphorus in the diet. “If you add 0.02% phytase, or 500 units per gram, it can replace 0.75% monocalcium phosphate. Based on current prices, this would save you about 50 cents per ton of feed,” Stein says.

“If you add phytase, you also need to decrease the calcium content. The calcium-to-phosphorus ratio should be 1 to 1 in diets containing phytase.”

Stein and Thaler recommend that swine producers check current prices with their local feedstuff company and calculate costs based on the total ration, taking into account necessary changes in amino acid and mineral supplements.◆



In breeding soybeans to meet South Dakotans' needs, Roy Scott relies equally on the latest updates in biotechnology and computer science and on his own observations and judgments in the field.

# Crop varieties

## of tomorrow with biotechnology

by Lance Nixon

**The ancient practice of seed selection** meets 21st century plant breeding on the grid of an Excel spreadsheet in Roy Scott's electronic fieldbook.

"Selection was happening for thousands of years before plant breeding came along," says Scott, a soybean breeder at South Dakota State University. "We just do it differently.

"When you have 12,000 test plots, you've got to computerize it just to be able to handle the numbers."

Plant breeding has changed greatly in the past 10 years because of advancements in molecular science and biotechnology, Scott says.

Yet it still looks back to ancient roots.

"The first plant breeders were women. Almost without a doubt," says Fred Cholick, dean of South Dakota State University's College of Agriculture and Biological Sciences and former spring wheat breeder.

"They were the ones doing the gathering back in the days of the hunter-gatherers, so they were the ones selecting the seeds."

It's far more complex now than just selecting the best seeds. But Cholick adds that some of the goals remain essentially unchanged. From its very beginning, plant breeding has tried to alter crops to make them more usable for humans—sometimes going against the plants' own survival mechanisms.

Hunter-gatherers selected plants that wouldn't shatter and spill their grain, for example, although that shattering mechanism was part of what the plant did to spread its seed so the new generation could survive.

And Amir Ibrahim, working toward the release of South Dakota State University's first hard white winter wheat, has been wrestling with a survival mechanism called pre-harvest sprouting—the wheat seed wants to sprout while still attached to the mother plant.

**BIOTECHNOLOGY PUTS MORE TOOLS** into the hands of plant breeders so they can make changes in crops more efficiently.

"When I think back on what I did as a plant breeder, I was using a sledgehammer approach," Cholick says. "I see biotechnology as more of a tweezers approach."

Ibrahim agrees. He notes that some facets of biotechnology have been controversial with some consumers, such as the creation of "transgenic" crops that add genetic material from other organisms to bring more desirable traits into the mix. The most familiar examples to South Dakotans are glyphosate-tolerant soybeans, a transgenic crop modified so that the crop will tolerate the herbicide glyphosate, and Bt corn, a transgenic crop modified to be lethal to corn borers that attempt to feed on it. South Dakota State University, other land-grant universities, and the wheat industry are also progressing on development of glyphosate-tolerant spring wheat.

But Ibrahim says biotechnology as a tool gives plant breeders much better control, too, of traits already present in crops such as wheat, without creating transgenic crops. For example, marker assisted selection is making it easier to identify and track traits that are carried in certain genetic combinations.

Biotechnology will make it easier to do what plant breeders call "pyramiding"—accumulating different genes that have an additive effect in bringing about the same goal. For example, it is known from research in other states that at least three genes confer resistance to Russian wheat aphid in winter wheat, Ibrahim says. Biotechnology will make it easier to assemble those genes in one plant variety.

Karl Glover, South Dakota State University spring wheat breeder, plans to use molecular science, specifically marker assisted selection, to look for regions of DNA that wheat geneticists elsewhere have linked to leaf rust resistance genes.

Glover's training in molecular science enables him to find those DNA regions when wheat seedlings are still very small, as soon as they produce sufficient leaf tissue for DNA analysis. He doesn't have to wait for the plants to grow to near maturity and then infect them with leaf rust to look for resistance genes that are only active in adult plants.

Glover says the time will come very soon when plant breeders, using the tools of biotechnology, will be adding specific traits to crops such as wheat that carry big benefits for consumers.

"I think it will happen within the next decade," Glover says. "The sticking point is that I don't know what the trait will be. Perhaps it will be a gene that would increase levels of some vitamin or perhaps an amino acid."

**DEVELOPING NEW CROP VARIETIES** will continue to be a key part of what South Dakota State University does simply because it pays off for producers, says Cholick.

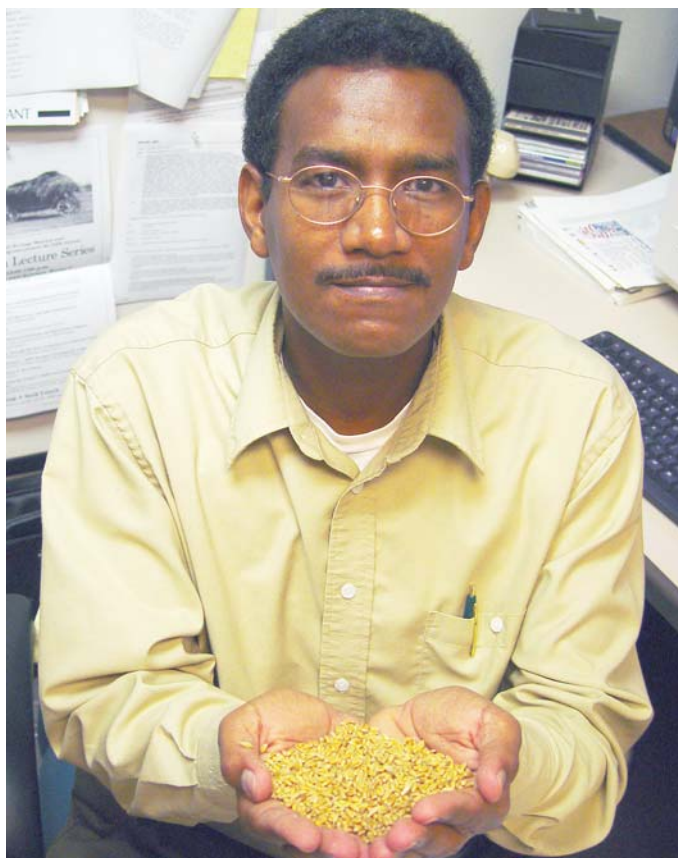
About 50% of advancement in yield comes from the plant genetics built into a particular variety, Cholick says, while the other 50% comes from management.

"The plant breeders' role is to put into the production system that genetic component that the producers need," Cholick says.

To think of it another way, plant breeders develop new crop varieties that stand up to the wide range of weather and soil conditions, pests, and plant diseases that occur in South Dakota. Plus, those varieties fold in desirable traits that producers and their customers are looking for.

Kathleen Grady, South Dakota State University oilseed crop breeder, selects sunflowers for a range of factors that include high seed yield, total oil content, oil composition, disease and insect resistance, standability (good stalk strength), and maturity.

She's also working to develop "NuSun" sunflowers—a name chosen by the National Sunflower Association to describe sunflower seeds and sunflower oil higher in oleic



Plant breeding "is both an art and a science," says Amir Ibrahim, SDSU winter wheat breeder, also citing the contributions of scientists in related fields.

acid and lower in linoleic acid than traditional sunflowers. NuSun varieties produce a mid-oleic oil higher in mono-unsaturated fat than conventional sunflower oils—and more in demand by health-conscious consumers.

Scott also keeps oil content in mind. "Because we have a crushing plant in Volga, we feel we have an obligation to create high-protein, high-oil soybeans for producers to grow for the soybean-crushing market," he says.

He adds, "With our location, we also face some unique soil conditions that may prevent soybeans from growing very well. One of these is iron chlorosis."

Scott carries on two separate breeding programs to serve producers who want two distinct products—conventional

**"We have a challenge. We have to continuously come up with a cultivar that has higher yield potential, superior qualities, and disease resistance, in addition to environmental stress tolerance. That means that as a plant breeder you have to beat yourself. Every time."**

—AMIR IBRAHIM,  
SDSU WINTER WHEAT BREEDER



Kathy Grady is SDSU oilseed crop breeder selecting sunflower lines for yield, oil content and composition, and stalk strength. Part of her work is in collaboration with scientists from the USDA Northern Crop Science lab in Fargo, N.D.

soybean varieties, as well as biotech varieties that are tolerant to the herbicide glyphosate.

Although it releases no hybrid seed corn, South Dakota State University also has a corn-breeding program to develop inbred lines, specialty corn, and germ plasm used by industry in developing new hybrids for farmers. South Dakota State University receives funding from the South Dakota Corn Utilization Council for this work, which is directed by Zeno Wicks III.

Plant breeders also look ahead at possible new markets for area producers. Ibrahim, for instance, anticipates that South Dakota State University's first hard white winter wheat will be released in 2003 or 2004, enabling area producers to sell to a niche in the market they've never been able to fill before.

Hard white wheat, which is used in making oriental noodles, can also be used in whole wheat bread because it tastes less bitter than red wheat and because it "looks nicer," Ibrahim says. It also allows for better flour extraction because millers can mill closer to the bran than with other wheats.

**NO MATTER** what the crop is, plant breeders typically have several of the same priorities in mind:

- Good yield and yield stability, or the ability of the crop to perform well across varying environments;

- Superior quality—good milling and baking qualities in winter wheat varieties, for example;
- Resistance to diseases and/or insects;
- Tolerance to environmental stresses, such as cold, heat, or drought.

"We have a challenge. We have to continuously come up with a cultivar that has higher yield potential, superior qualities, and disease resistance, and we also have to plan for environmental stress tolerance. That means that as a plant breeder you have to beat yourself. Every time," Ibrahim says.

Plant breeders agree that's not possible through science and the latest technology alone. Plant breeders also need to spend long hours with their plants, making detailed observations and using an ancient tool that is more sophisticated than it sounds—common sense.

"Plant breeding is both an art and a science," Ibrahim says. "It requires a knowledge of botany, genetics, agronomy, biotechnology, statistics, computer science, biochemistry, entomology, plant pathology.

"That's more than one person alone can handle.

"We plant breeders don't work alone. We absolutely must have the collaborative support of plant pathologists, entomologists, agronomists, molecular geneticists, cytogeneticists, statisticians, greenhouse managers, and our field crews.

“But even if it all comes together for a breeder and he has perfect science, he will not be successful unless he has that art that I’m talking about.”

Ibrahim explains that plant breeders are working with thousands of segregating populations and that they must choose among those populations by both analytical methods for yield, plant height, heading date, and by simple, but trained, observation. That is where art and common sense come in—and why Roy Scott’s electronic fieldbook is full of

little initials and notes about his 12,000 test plots. A little “G” or “VG” beside a test line means “good” or “very good.”

“Even if something yielded well, I might have a nasty note about it: ‘Lodged,’ ‘Didn’t stand up well.’ When I see that, I won’t select it.”

Using science, art, and long hours in the field, South Dakota State University plant breeders are working to create the crop varieties of tomorrow for the producers of South Dakota. ♦

# The newest varieties

The Agricultural Experiment Station plant breeding programs released several new crop varieties in 2002:

## Soybeans

‘**Spink**,’ a conventional variety named for Spink County, is released mainly for its high yield potential (an average of 45.5 bushels an acre in trials) and its iron chlorosis tolerance. Spink has good emergence, lodging resistance, and shattering scores. It carries a gene for resistance to *Phytophthora* root rot.

‘**SD1081RR**’ is a glyphosate-tolerant variety released mainly for its high yield potential, iron chlorosis tolerance, and tolerance to glyphosate herbicide. SD1081RR has yielded an average 39 bushels an acre in trials. It has about 40% protein and 20% oil. It carries a gene for resistance to *Phytophthora* root rot.

Applications for plant variety protection on both varieties have been made. The South Dakota Soybean Research and Promotion Council uses check-off funds to help support South Dakota State University’s soybean research, including the development of new varieties.

## Oats

‘**Buff**’ is the first hullless oat release from South Dakota State University since the 1950s.

Buff heads approximately 7 days earlier than ‘Paul,’ a hullless variety released by North Dakota and currently the most popular naked oat grown in South Dakota. South Dakota State University trials show Buff yielded better than Paul in 2002 and over the past 3 years.

Buff is resistant to smut, moderately susceptible to crown rust, susceptible to stem rust, and moderately susceptible to moderately resistant to barley yellow dwarf.

‘**Reeves**’ is a white-hulled spring oat similar in maturity to ‘Don,’ a commonly grown variety in South Dakota.

Reeves has a higher yield potential, test weight, and protein than Don. Reeves is approximately 5 inches taller and has better crown rust resistance.

Quaker Oats helps fund South Dakota State University’s oat research, including the development of new varieties.

## Spring wheat

‘**Briggs**’ is a spring wheat released in 2002 and named in honor of the late Hilton Briggs, South Dakota State University president from 1958 to 1975. Briggs was one of the top-yielding wheats at 33% of locations tested in 2002, making it one of the year’s top performers.

Over the past 3 years, Briggs has been in the top-yielding group at 83% of trial locations. It is resistant to leaf rust and stem rust; it has a mixed or intermediate reaction to *Fusarium* head blight.

South Dakota State University is applying for plant variety protection for Briggs. The South Dakota Wheat Commission helps fund South Dakota State University’s wheat research, including the development of new varieties.

## Winter wheat

‘**Expedition**’ is a hard red winter wheat released to seed producers in 2002. Its name commemorates the Lewis and Clark expedition that explored the western U.S., including South Dakota, from 1804 to 1806.

Expedition has excellent winter survival ability and high yield potential in South Dakota and the northern Great Plains. It is an awned, white-chaffed, early maturity, semi-dwarf variety with a broad disease-resistance package and excellent milling quality.

Expedition is targeted to replace ‘Alliance’ and ‘2137’ across the traditional winter wheat growing areas in South Dakota.

The South Dakota Wheat Commission helps fund South Dakota State University’s wheat research, including the development of new varieties.



# Gene transfer

## rarely happens between soybeans varieties

by Marianne Stein

### **Should growers and consumers worry about the chances of cross-pollination between transgenic and non-transgenic soybean plants in the field?**

Teams of scientists at South Dakota State University examined possible outcrossing and also any effects that might show up in pigs fed transgenic soybeans. They examined foods from the soybeans for presence of the transgene.

A transgenic plant or animal contains a gene from an outside source. Glyphosate-tolerant soybeans carry a gene from the common soil bacterium *Agrobacterium tumefaciens*, modified in the laboratory to heighten its activity in the soybean.

Avoiding cross-pollination from transgenic plants is crucial for certified organic growers, as they risk losing their certification if their product contains traces of genetically modified seeds.

“The organic marketplace does not want to accept tolerance levels of contamination from genetically modified organisms,” said Jim Stiegelmeier of Selby, a certified organic producer of soybeans and other crops.

“In the organic community any presence of transgenes

**“A distance of at least 20 feet between an organic producer and neighboring fields may be sufficient to eliminate the risk of outcrossing from transgenic to non-transgenic soybeans, though it would not eliminate contamination by mechanical means.”**

—CATHERINE CARTER,  
SDSU PLANT SCIENCE PROFESSOR

is considered a very serious problem. Some people object to consuming genetically modified products because they feel it is beyond the realm of natural selection, and they do not know what the consequences might be. Some people may also have religious concerns,” he added.

**ABOUT 89% OF SOYBEANS** grown in South Dakota are transgenic glyphosate-tolerant varieties, genetically engineered to contain a protein that makes them tolerant of the herbicide glyphosate. The remaining 11% of South Dakota soybeans are not genetically engineered varieties.

The likelihood that soybeans of any variety cross-pollinate is extremely small, said Catherine Carter, professor of plant science at South Dakota State University.

“In most cases, a soybean plant receives pollen from itself. Cross-pollination only occurs at a frequency at about 1%.”

Soybeans are not wind-pollinated, but a small amount of pollen transfer may occur via insects, added Roy Scott, professor of plant science. “We were interested in studying

if there is any natural outcrossing between glyphosate-tolerant and conventional soybean plants in neighboring fields,” Scott said.

The soybean varieties used in the South Dakota State University trials were developed by Scott, who is a soybean breeder. “The two types of soybean plants we used in this study were so-called isolines,” he explained. “This means that they shared the same genetic makeup except for the presence of the transgene in one of them.”

Carter explained, “This allowed us to conduct a trial where we were not just comparing glyphosate-tolerant and conventional soybeans, because they could be different in many other ways; we are comparing two varieties that are almost identical. Thus, we were able to eliminate complications that may be caused by other genetic differences.”

**THE SCIENTISTS STUDIED** pollen dispersal of transgenes in two field trials conducted in 2000 and 2001.

The 2000 experiment consisted of bordered plots in which the glyphosate-tolerant soybeans were surrounded by non-transgenic soybeans. Rows were harvested by a two-row small plot combine. At least 5500 seeds were collected from each plot, cleaned, and tested for traces of the transgene.

Plot samples were divided into 10 or 11 subsamples, each containing 500 seeds. “They were tested by three different methods,” explained Carter, “a polymerase chain reaction (PCR), a strip test, and a seed germination test.”

PCR analysis uses a gene primer, which makes it possible to detect the presence of the gene for glyphosate tolerance in seeds. The strip test detects the presence of the altered protein that makes the plant tolerant to the herbicide. The seed germination test analyzes seeds for tolerance to the herbicide, as seeds that are able to tolerate glyphosate must contain the modified gene.

The transgene was found in 16 of the 21 plots surrounding the transgenic soybean plots. Positive samples of the transgene were found in all plots immediately adjacent to the transgenic plots. Samples from all except one of the plots that were not directly adjacent to a transgenic plot contained no traces of the gene for glyphosate tolerance.

Less than 1% of the seed from any plot contained the transgene, according to PCR analysis. The strip test method detected the presence of the protein for glyphosate tolerance in nine of the conventional plots. Germination



Part of the procedure to extract DNA from soybean seeds is a good, long soak in a water incubator, explains Stephanie Hansen, research associate in Carter's laboratory.

tests conducted by Brent Turnipseed, South Dakota State University Seed Testing Lab manager, found transgenic seed in 6 of the 21 plots at levels ranging from 0.25 to 1.75%.

The differences have to do with the accuracy of test methods.

"The PCR test is much more sensitive than the other methods and can detect the transgene at levels as low as one seed in 10,000," Carter said.

Carter pointed out that some of the positive readings in the test may have occurred through mechanical contamination. When the soybeans were harvested, the combine may have carried a few seeds from a transgenic plot into the adjacent one.

In fact, the movement and direction of the combine indicates that this may indeed have been the case, as the plots harvested immediately after the transgenic plots showed the highest incidence of transgenic seeds.

Mechanical contamination could also have happened during planting or when the seed was handled after harvest, Carter says.

To reduce the occurrence of mechanical contamination, seeds in the 2001 trial were harvested by hand.

The plot design in the 2001 trial consisted of four rows of conventional soybeans with four rows of transgenic soybeans on each side. Data were analyzed by the same methods as in the first trial, but the PCR test was done on each seed, giving a more accurate picture of the actual percentage of transgenic seeds in the sample.

PCR tests have not been completed. Seed germination tests found an average of less than 2% cross pollination.

**THE POSSIBILITY OF MECHANICAL** contamination raises difficulties for a producer growing both organic and transgenic soybeans.

Doug Stengel, Milbank, has both certified organic and non-organic fields; however, he does not produce soybeans on the organic land because of the risk of mixing with transgenic seed production from his non-certified land.

"It would be impossible to keep everything separated through the whole process of growing, harvesting, storing, and conditioning," he said.

However, the South Dakota State University trials indicate that cross-pollination in the field is very limited. "A distance of at least 20 feet between an organic producer and neighboring fields may be sufficient to eliminate the risk of outcrossing from transgenic to non-transgenic soybeans, though it would not eliminate contamination by mechanical means," Carter concluded.

Other participants in the project included Leon Wrage, South Dakota State University Extension distinguished professor of plant science, and Tom Cheesbrough, department head of biology/microbiology.

The project was funded by the South Dakota Agricultural Experiment Station and grants from the South Dakota Soybean Council and the South Dakota Legislature.◆

*Jim Stiegelmeier, Selby area certified organic producer who contributed to this story, died in an accident last summer. His family requested that, because Jim believed so strongly in organic farming, his comments remain in the story.*

## Swine feeds, human food products tested

A hundred feeder pigs were divided into two groups and fed diets based on the soybeans used in the field experiment. One group received a diet based on transgenic soybeans and the other the same diet but with non-transgenic soybeans.

The scientists measured daily gain, feed intake, feed efficiency, and gross carcass characteristics such as backfat thickness and percent lean.

"We found no differences between the two groups," said Bob Thaler, South Dakota State University Extension swine specialist.

"Growth was normal and identical for both groups.

"We also looked for traces of the transgene in the swine carcasses and did not find it; thus we confirm that the transgene was not present in the meat."

Human food products made from transgenic and non-transgenic soybeans were also tested.

"We looked at protein content, fat content, and total mineral

content and found no differences," said Padmanaban Krishnan, professor of food science.

"We found that the gene from seed collected from the transgenic plots was present in soymilk but not in tofu made from the milk. It was present in soybean flour and in some bread loaves made from the flour but not in the bread crust, probably because of the heating process," said Krishnan.

Krishnan and Carter agreed that transgenic soybeans do not pose any health risks to humans or animals. "When you eat a food that contains the typical components of a plant, you're eating protein and DNA. The altered protein in the transgenic plants is very similar to the naturally occurring protein and would be digested similarly," Carter said.



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